DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
NATIONAL WEATHER SERVICE
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OFFICE NOTE 225

A Further Note on Tuning the LFM Gradient Wind Relation

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Introduction

This note is intended to refine and extend the results of Office Note 222. In that paper, heights analyzed by the Hough analysis scheme and output on a 1-Bedient 65-by-65 grid were used to compute gradient winds. By varying a parameter in the gradient wind equation and repeatedly calculating winds, an optimum value of the parameter was chosen. This process is repeated in the current paper. This time, however, the calculations are done at 4 pressure levels on both the 1-Bedient 65-by-65 grid again using Hough height analyses, and on the 1/2-Bedient 53-by-57 grid using height analyses from the LFM (Cressman type analysis), and a larger number of cases than was used in the previous note.

In the LFM, gradient winds are calculated from height analyses. These wind fields are then used as a guess for the wind analysis.

The gradient wind equations are:

$$u_* = u_g - \frac{k_1 k_2}{f}\left(\frac{\partial K_g}{\partial y} + u_g \, \zeta_g\right) \qquad (1)$$

$$v_* = v_g + \frac{k_1 k_2}{f}\left(\frac{\partial K_g}{\partial x} - v_g \, \zeta_g\right) \qquad (2)$$

Where u_*, v_* = gradient wind components

u_g, v_g = geostrophic wind components

K_g = $1/2 \, (u_g{}^2 + v_g{}^2)$

ζ = $\partial v_g/\partial x - \partial u_g/\partial y$

f = coriolis parameter

k_1 = constant, determined by experiment

L = latitude

k_2 = $\dfrac{\text{Sin } L - \text{Sin } 20}{\text{Sin } 30 - \text{Sin } 20}$, $0 \le k_2 \le 1$, $20° \le L \le 30°$

(See Office Note 222 for derivation).

Procedure

The objective of this study was to determine the optimum value of the parameter k_1 in equations (1) and (2). In order to evaluate the effects of differing analysis methods and grid sizes, two sets of wind calculations were made for each synoptic case chosen, one set of calculations from Hough height analyses on the 1-Bedient grid, and one set of calculations from Cressman height analyses on the 1/2-Bedient grid. For each set of gradient winds calculated, the RMS vector error and the mean error, or bias, of these winds (gradient versus observed winds) were calculated over the 110 station NA110 network using the SUMAC verification program. Graphs of these statistics as functions of pressure and of parameter k_1 were then constructed, an example of which is shown is Figure 1. Typically, the RMS vector error first decreased with increasing k_1, reaching a minimum for values of $0.08 \leq k_1 \leq 0.26$ and then began increasing. The bias, on the other hand, exhibited a monotonic variation with increasing k_1. For a particular case, the value of k_1 corresponding to the minimum value of the RMS at a given level was chosen as the optimum value of k_1 for that level.

Results

Figure 2 permits a comparison between optimum values of k_1 (denoted k_1^*), as determined from simultaneous calculations on the 1- and 1/2-Bedient grids. The average value of k_1^* at 250 mb is $k_1^* = 0.14$. The small scatter and the orientation of data points along the diagonal from the origin indicate that, for the twelve cases considered, approximately the same value of k_1^* would result regardless of which of the two grids/ analysis systems were used for the wind calculations.

The statistics for all the calculations on the 1/2-Bedient grid have been summarized in Figures 3 and 4 by averaging the RMS vector error and the bias over all the cases and plotting them as functions of pressure and k_1. Three additional 1/2-Bedient cases were available and were included in the average. Values of k_1 deemed appropriate for operational use in the LFM as determined from these statistics are listed in Table 1, along with the values of k_1 currently in use operationally. These values are very similar to those presented in Office Note 222.

Conclusions

The results of this study confirm that parameter k_1 may be determined from gradient wind calculations from Cressman or Hough height analyses on either a 1/2-Bedient or a 1-Bedient grid, respectively. The "NEW" values of k_1 in Table 1 will be implemented in the LFM at the next available opportunity.
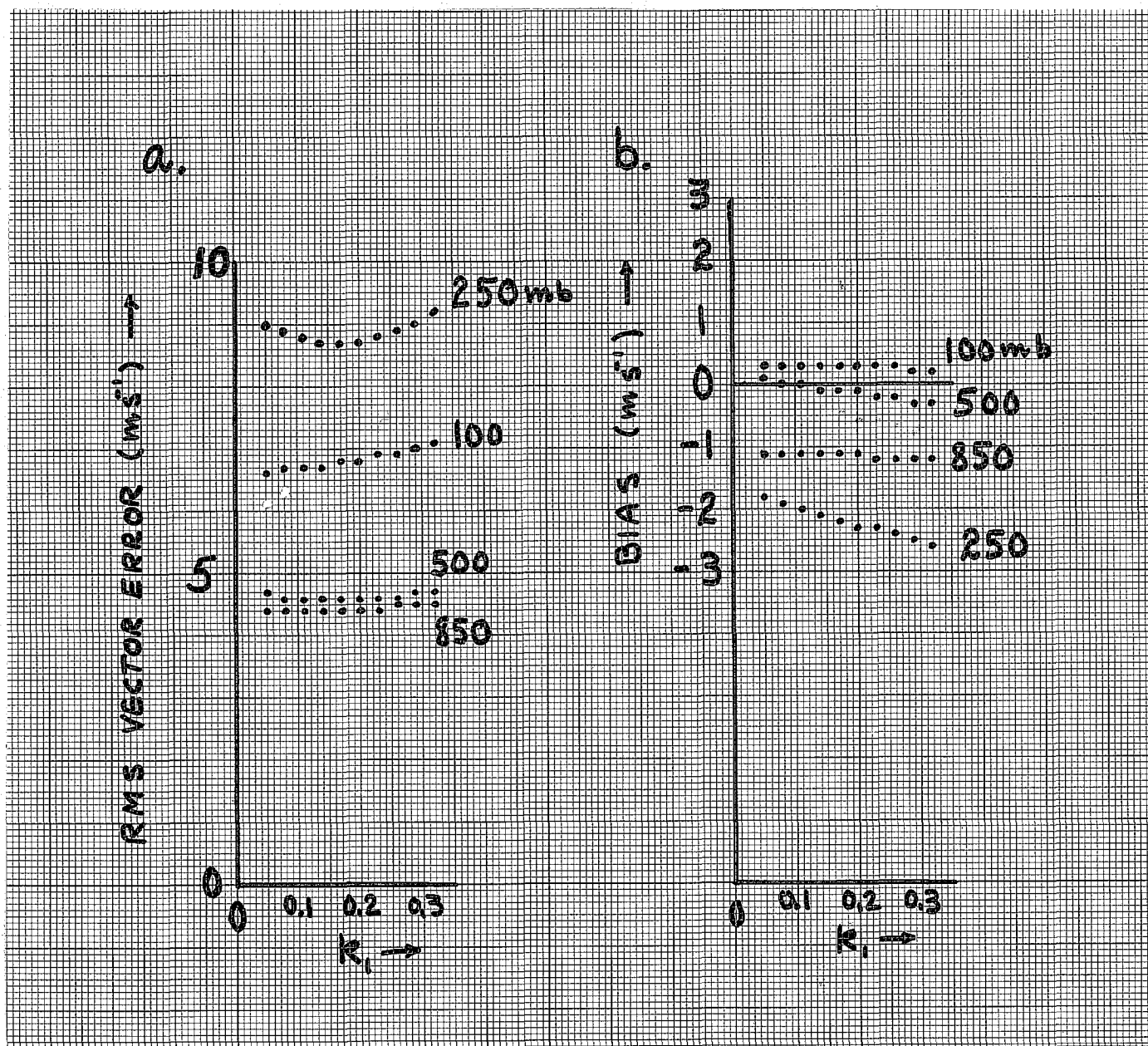
Figure 1. Error statistics (gradient vs observed wind)
for 00Z 30 September 1979, on 1/2 Bedient grid.
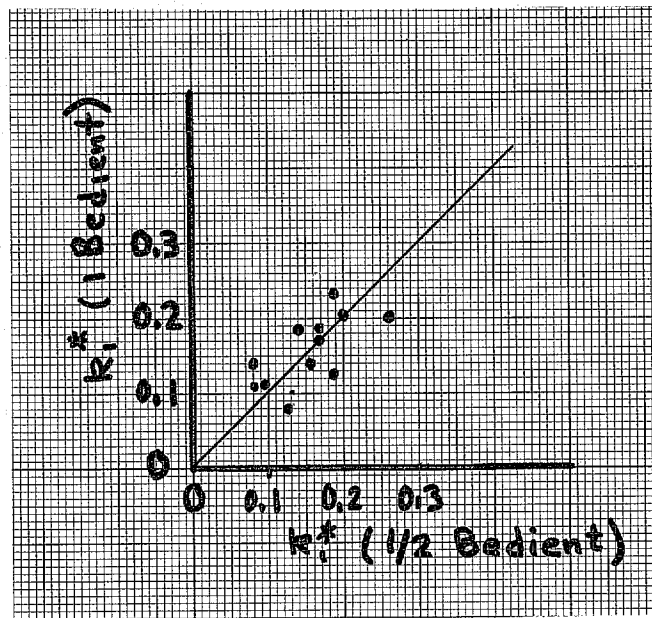a) RMS vector error (ms^{-1}),
b) bias (ms^{-1})

Figure 2.   Optimum value of gradient wind parameter
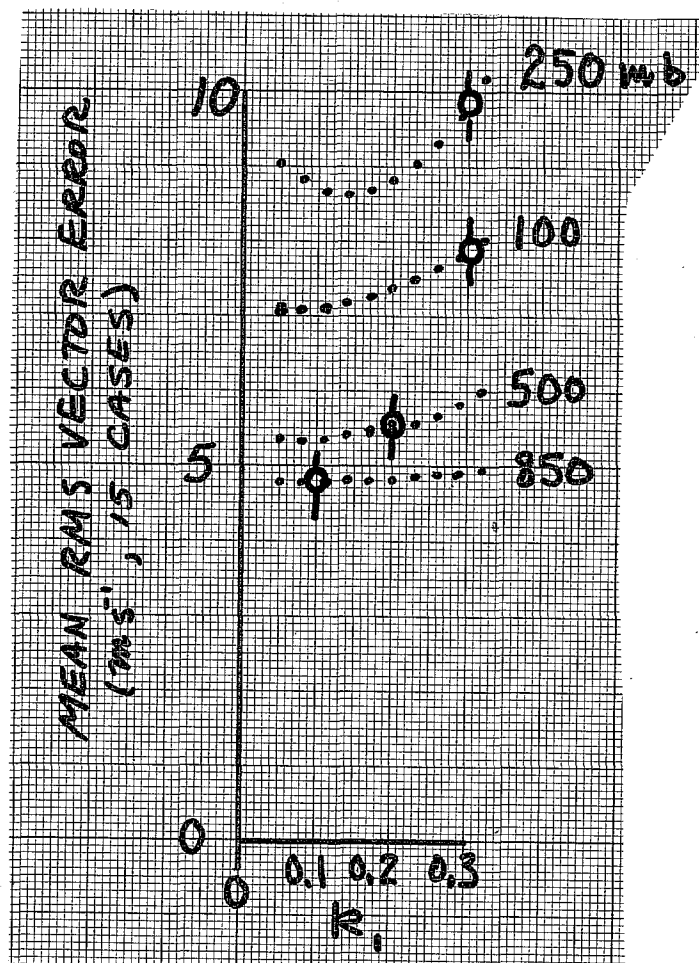1-bedient values vs 1/2 bedient values.

Figure 3. Average RMS vector error for 15 cases versus k_1.
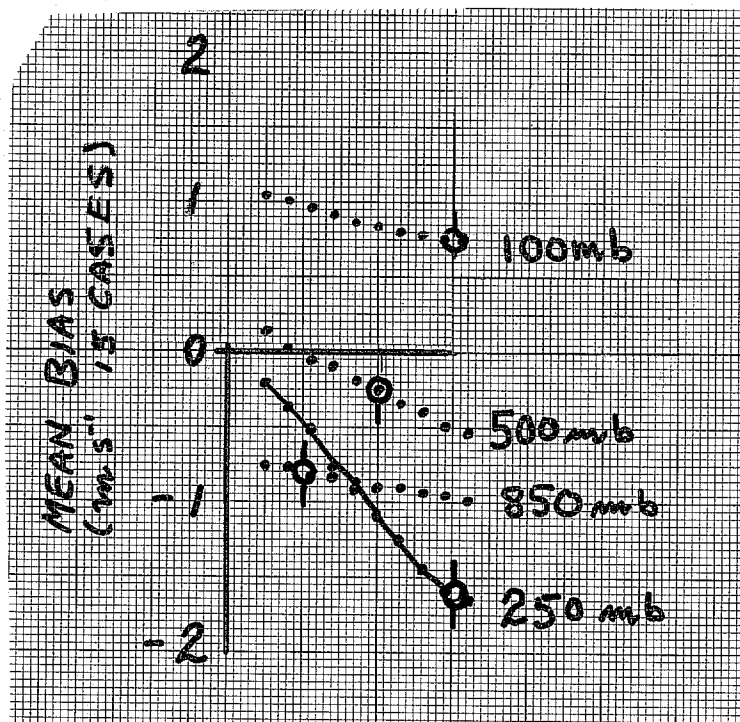Overplotted circle indicates value of k_1 currently
in use in the LFM.

Figure 4.   Average bias for 15 cases versus k_1.   Overplotted
circle indicates value of k_1 currently in use in
the LFM.

Table 1. Comparison of Appropriate New and Current Values of

Gradient Wind Parameter k_1

PRESSURE (mb)	CURRENT	k_1 NEW
850	0.10	0.10
500	0.20	0.15
250	0.30	0.15
100	0.30	0.15

Reference

A Note on Tuning the Gradient Wind Relation Currently used in the LFM.
NMC Office Note 222, August 1980.